# Natural Conditions Assessment for low DO, Deep Creek Nottoway County, Virginia

**Submitted by**

**Virginia Department of Environmental Quality**

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# Executive Summary

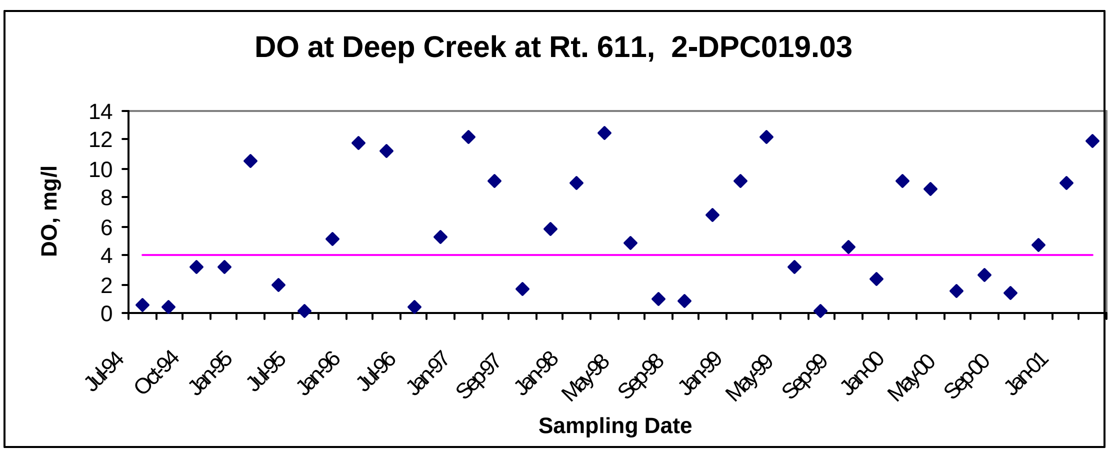
This report presents the assessment of whether low dissolved oxygen (DO) in the Deep Creek watershed is due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Deep Creek is located in Amelia and Nottoway Counties in the Appomattox River Basin (USGS Hydrologic Unit Code 02080207). The waterbody identification code (WBID, Virginia Hydrologic Unit) for Deep Creek is VAP-J11R. There are 285 total stream miles in the Deep watershed (National Hydrography Dataset (NHD).

The drainage area of the Deep Creek watershed is approximately 205 square miles. The average annual rainfall is 44.27 inches. The watershed is approximately 131,369 acres in size, and is predominately forested (67.7 percent). Agriculture encompasses 24.9 percent of the watershed, with 2.7 percent cropland and 22.2 percent pasture/hayland. Residential and high use industrial areas compose approximately 1.1 percent of the land base. The remaining 6.4 percent of the watershed is comprised of 3.5 percent of transitional areas and 2.9 percent wetlands and open water.

There are three impaired segments totaling 26.08 stream miles. The three impaired segments are VAP-J11R-01, 7.41 miles in mainstem Deep Creek from the confluence with Spindlers Run downstream to the confluence with Beaverpond Creek, impaired for fecal coliform bacteria; VAP-J11R-02, 16.54 miles of Deep Creek from its headwaters downstream to its confluence with Cellar Creek, impaired for low DO and fecal coliform bacteria; and VAP-J11R-03, 2.13 miles of an Unnamed Tributary of Deep Creek from its headwaters downstream to its confluence with Deep Creek at rivermile 24.42, impaired for general standard - benthic. This report addresses only the DO impaired segment, VAP-J11R-02. The bacterial and benthic impairments are reported in a separate document.

Deep Creek was listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for dissolved oxygen (1998). A total of 36 DO data points, with 16 water quality standard violations (47.1%), were taken by DEQ at station 2-DPC019.03 (see Figure E1) from July 27, 1994 through March 8, 2001.

**Figure E1. Time series of DO concentrations (station 2-DPC019.03), July 1994 to March 2001.**




According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Deep Creek must support all designated uses and meet all applicable criteria. The Deep Creek does not appear to support aquatic life use because of DO water quality standard violations.

VADEQ proposes a methodology for determining whether low DO originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia." (MapTech 2003)

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process.

These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure for low DO, all DO data should be screened for flows less than the 7Q10. DO data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

No low DO violations occurred below 7Q10 at listing station 2-DPC019.03, therefore no DO violations were eliminated at this site.

Deep Creek exhibits low slope (0.12%) and large areas of swamps in the area of the original listing station. The approximate upstream and downstream boundaries of this low slope segment on mainstem Deep Creek are from the confluence with Winningham Creek at RM 20.18 downstream to the confluence with Little Creek at RM 14.64. The low slope in this 5.54 mile segment contributes no human impact. Decomposition of the large inputs of decaying vegetation from this large swampy area increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

Deep Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which not indicative of human impact.

Deep Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high.

Of the seven permitted dischargers in the Deep Creek watershed upstream of the original listing station, only the Crewe STP located on a UT to Deep Creek 7.5 miles upstream is of sufficient flow to consider the possibility of impact. On average, Crewe STP effluent comprises approximately 5% of flow at 2-DPC019.03. Therefore potential effect more than seven miles downstream at the listing station from the Crewe STP flow will be minimal. Further, low nutrients, BOD5 and TSS at 2-DPC019.03 show that the discharge has no significant anthropogenic impact on the low DO impaired segment. EPA approved a benthic TMDL for the UT to Deep Creek below this STP in 2004, with the stressor identified as overflows from the town sewer system. This facility had solids discharge events in the 1980's and early 1990's that impacted the UT to Deep Creek, however adverse impact to mainstem Deep Creek was not documented.

The town upgraded the STP in 1997, and the most recent benthic assessment in 2002 indicated no impairment. This UT is 5.4 miles above the original low DO listing station. Therefore solids releases in the UT to Deep Creek below Crewe STP in the 1980's and early 1990's probably have no current impact in the swampy segment in mainstem Deep creek more than five miles downstream. Residential / Commercial land use (1.06%) probably has no DO effect on streams in the watershed. The watershed is predominately forested (67.7%).

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for mainstem Deep Creek from the confluence with Winningham Creek downstream to the confluence of Little Creek, a distance of 5.54 river miles. If there is a 305(b)/303(d) assessment prior to the reclassification, Deep Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Deep Creek low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

# 1. Introduction

Deep Creek in Nottoway County and a small portion of Amelia County was listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for dissolved oxygen (1998) and fecal coliform bacteria (2004). This report evaluates the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The bacterial impairment was addressed separately from this document.

A glossary of terms used throughout this report is presented as Appendix A.

2. Physical Setting

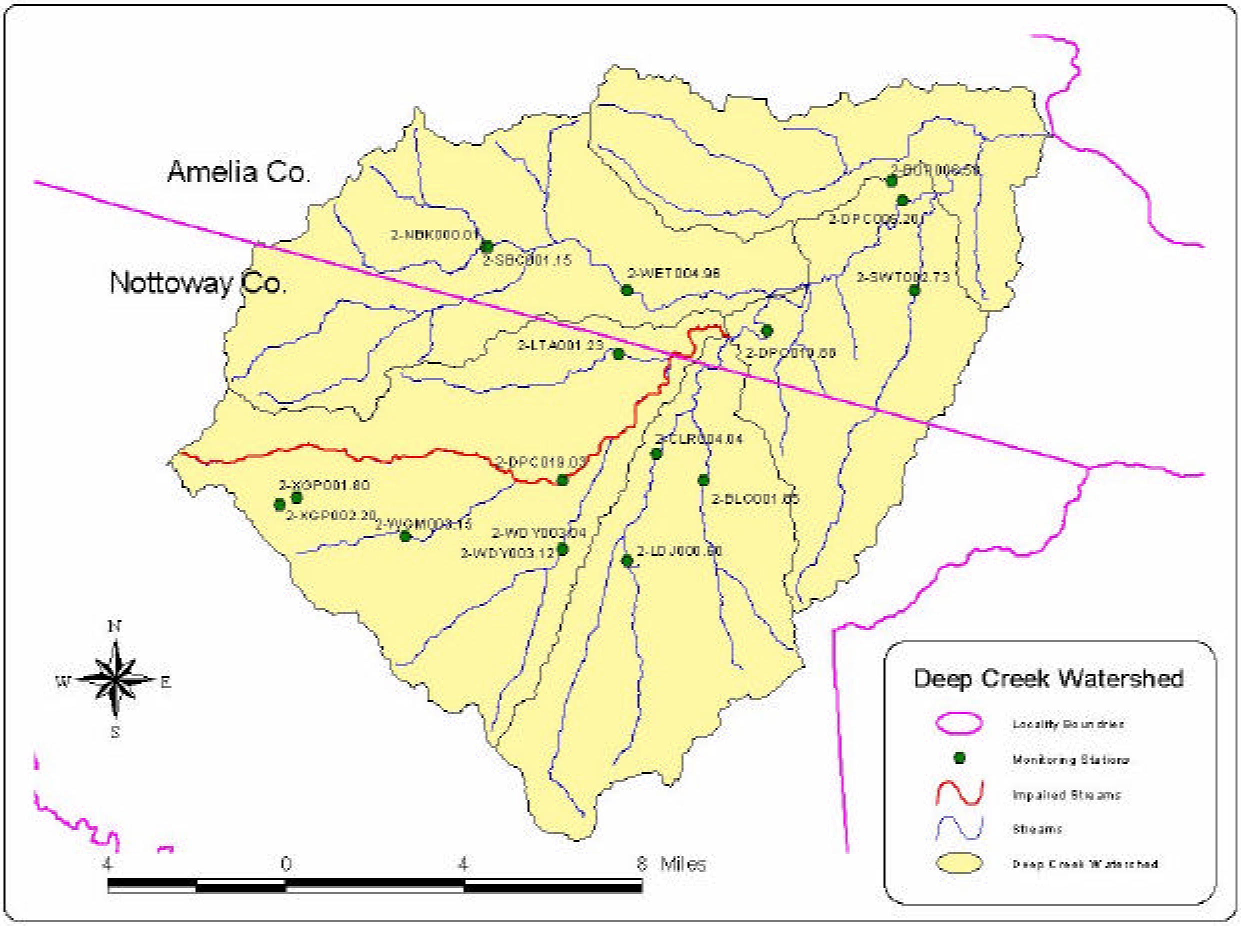
## *2.1 Listed Water Bodies*

Deep Creek is located in Nottoway and Amelia Counties in the Appomattox River Basin (USGS Hydrologic Unit Code 02080207). The waterbody identification code (WBID, Virginia Hydrologic Unit) for Deep Creek is VAP-J11R. There are 285 total stream miles in the Deep Creek watershed (National Hydrography Dataset (NHD). There are three impaired segments totaling 26.08 stream miles. The three impaired segments are VAP-J11R-01, 7.41 miles in mainstem Deep Creek from the confluence with Spindlers Run downstream to the confluence with Beaverpond Creek, impaired for fecal coliform bacteria; VAP-J11R-02, 16.54 miles of Deep Creek from its headwaters downstream to its confluence with Cellar Creek, impaired for low DO and fecal coliform bacteria; and VAP-J11R-03, 2.13 miles of an Unnamed Tributary of Deep Creek from its headwaters downstream to its confluence with Deep Creek at rivermile 24.42, impaired only for general standard - benthic. This report addresses only the DO impairment. The bacterial and benthic impairments are reported in a separate document. These segments are described in Table 1 and Figure 1.

**Table 1. Impaired segment descriptions (Deep Creek)**

| Segment (segment ID) | Impairment (source of impairment) | Upstream Limit Description | Downstream Limit Description | Miles Affected |
|---|---|---|---|---|
| Deep Creek VAP-J11R-01 | Fecal coliform (Unknown) | Spindlers Run confluence | Beaverpond Creek confluence | 7.41 |
| Deep Creek VAP-J11R-02 | Dissolved Oxygen Fecal coliform (Natural conditions, unknown) | Headwaters | Cellar Creek confluence | 16.54 |
| UT to Deep Creek VAP-J11R-03 | General Standard - benthic (PS - municipal) | Town of Crewe STP discharge | Deep Creek Confluence at rivermile 24.42 | 2.13 |

**Figure 1. Map of the Deep Creek study area.**




## *2.2. Watershed*

### 2.2.1. General Description

Deep Creek, located within Nottoway and Amelia Counties, is a major tributary to the Appomattox River. It is about 29 miles long and flows northeastward from its headwater near Crewe, VA, to its confluence with the Appomattox River. The watershed itself is approximately 22 miles long and 13 miles wide, having an area of 205 square miles. The major tributaries to Deep Creek are Beaverpond and West Creeks entering from the northwest, and Sweathouse, Cellar, and Woody Creeks entering from the south. There is a continuous flow gaging station on Deep Creek near Mannboro, VA, 02041000, with a drainage area of 158 mi$^2$, located downstream of the low DO impaired segment at rivermile 5.20.

### 2.2.2. Geology, Climate, Land Use

***Geology and Soils***

Deep Creek is in the Piedmont physiographic region. The Piedmont of Virginia extends eastward from the Blue Ridge to the Fall Line, where Paleozoic-age and older igneous and metamorphic rocks are covered by unconsolidated sediments of the Atlantic Coastal Plain. The Virginia Piedmont is part of the greater southeastern Piedmont, which extends from northeastern Alabama through Georgia, South Carolina, North Carolina, Virginia, Maryland, and southeastern Pennsylvania. The Piedmont is characterized by deeply weathered, poorly exposed bedrock and a high degree of geological complexity, making it one of the last frontiers of North American regional geology. The Piedmont contains a collage of rock associations or terranes that are bounded by northeast-trending regional faults. (http://www.geology.state.va.us/DOCS/Geol/pied.html).

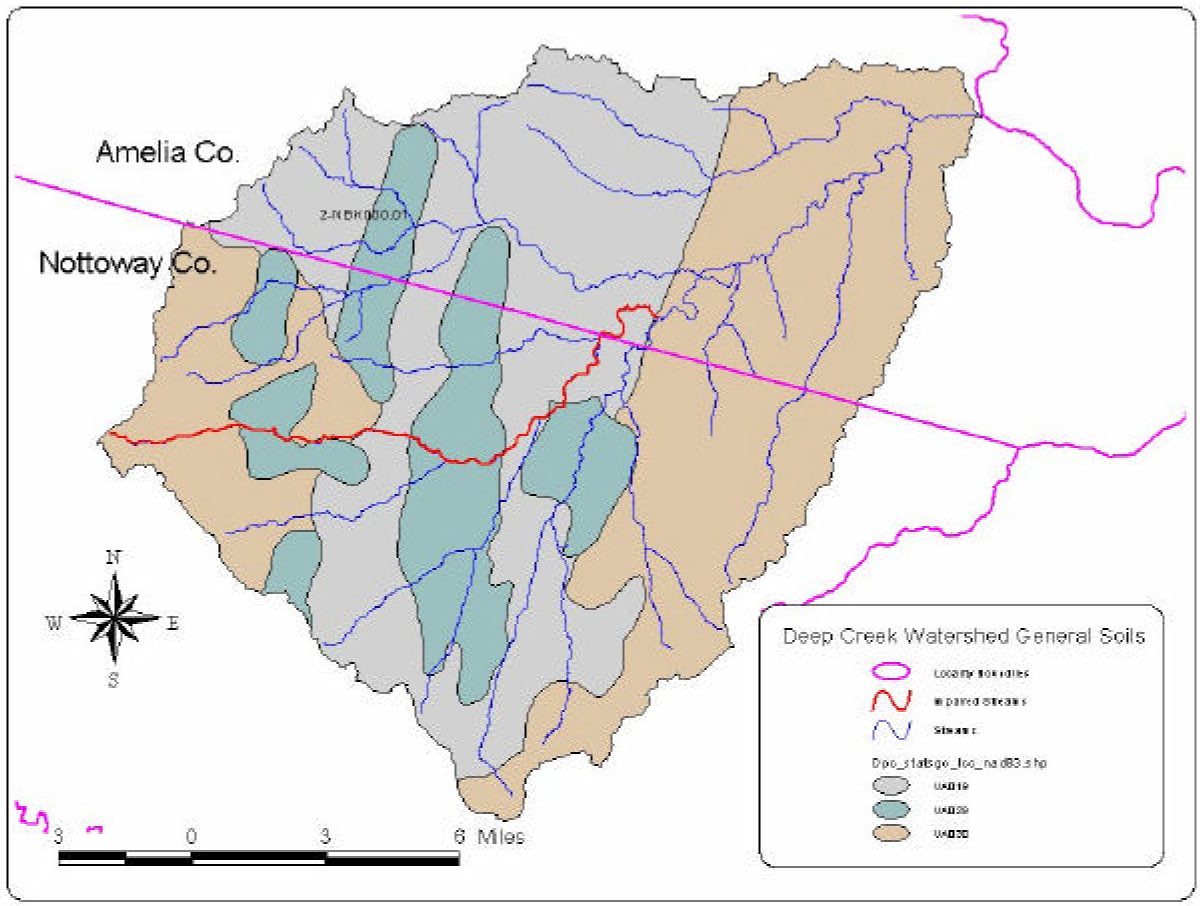
Soils for the Deep Creek watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi). Figure 2 shows the location of these general soil types in the watershed.

The **Cecil-Madison-Enon-Wilkes-Chewacla** series (**VA019**) are very deep to shallow soils which have been formed from residuum weathered from igneous and high-grade metamorphic rocks, or alluvium deposits of these same parent materials. Located in the Piedmont uplands, these soils are located on ridges and side slopes of the Piedmont uplands and floodplains. This series are moderately drained in the uplands and somewhat poorly drained in floodplains. Soils are moderate to slowly permeable.

Soils of the **Iredell – Pacolet – Chewacla – Poindexter – Wilkes – Orange - Goldston** series **(VA029)** are shallow to very deep, or weathered bedrock. They formed in residuum from intermediate and mafic crystalline rocks, weathered diabase, diorite, gabbro, other rocks high in ferro-magnesium minerals, from schist, gneiss, granite, phyllite, and other metamorphic and igneous rocks, basic rocks or a mixture of basic and acidic rocks, acid crystalline rocks of the Piedmont uplands, or from fine-grained metavolcanic rocks or felsic slates in the Carolina Slate Belt. Soils range from excessively well to somewhat poorly drained (in flood plains), with moderately rapid to very slow permeability.

Soils of the **Appling-Wedowee-Ashlar-Louisburg-Vance-Worsham** series **(VA030)** are moderate to very deep that formed in residuum from weathered igneous, metamorphic, and crystalline rock of the Piedmont Plateau. Soils range from excessively to poorly drained, with moderately rapid to slow permeability.

**Figure 2. Soil Characteristics of the Deep Creek Watershed.**




***Climate***

The climate summary for Deep Creek comes from a weather station located in Amelia, VA, with a period of record from 1/1/1970 to 3/31/2003. The average annual maximum and minimum temperature (°F) at the weather station is 68.9 and 44.3 and the annual rainfall (inches) is 44.27 (Table 2) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

**Table 2. Climate summary for Amelia, Virginia (440187)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average Max. Temperature (F)** | 46.6 | 50.4 | 59.2 | 69.6 | 77.0 | 84.9 | 88.5 | 86.8 | 81.1 | 70.8 | 61.0 | 51.3 | 68.9 |
| **Average Min. Temperature (F)** | 24.8 | 27.0 | 33.8 | 42.2 | 51.5 | 60.5 | 64.8 | 63.1 | 56.0 | 43.6 | 35.5 | 28.3 | 44.3 |
| **Average Total Precipitation (in.)** | 3.50 | 3.24 | 4.35 | 3.20 | 3.81 | 3.18 | 4.41 | 4.07 | 3.83 | 4.06 | 3.64 | 2.98 | 44.27 |

***Land Use***

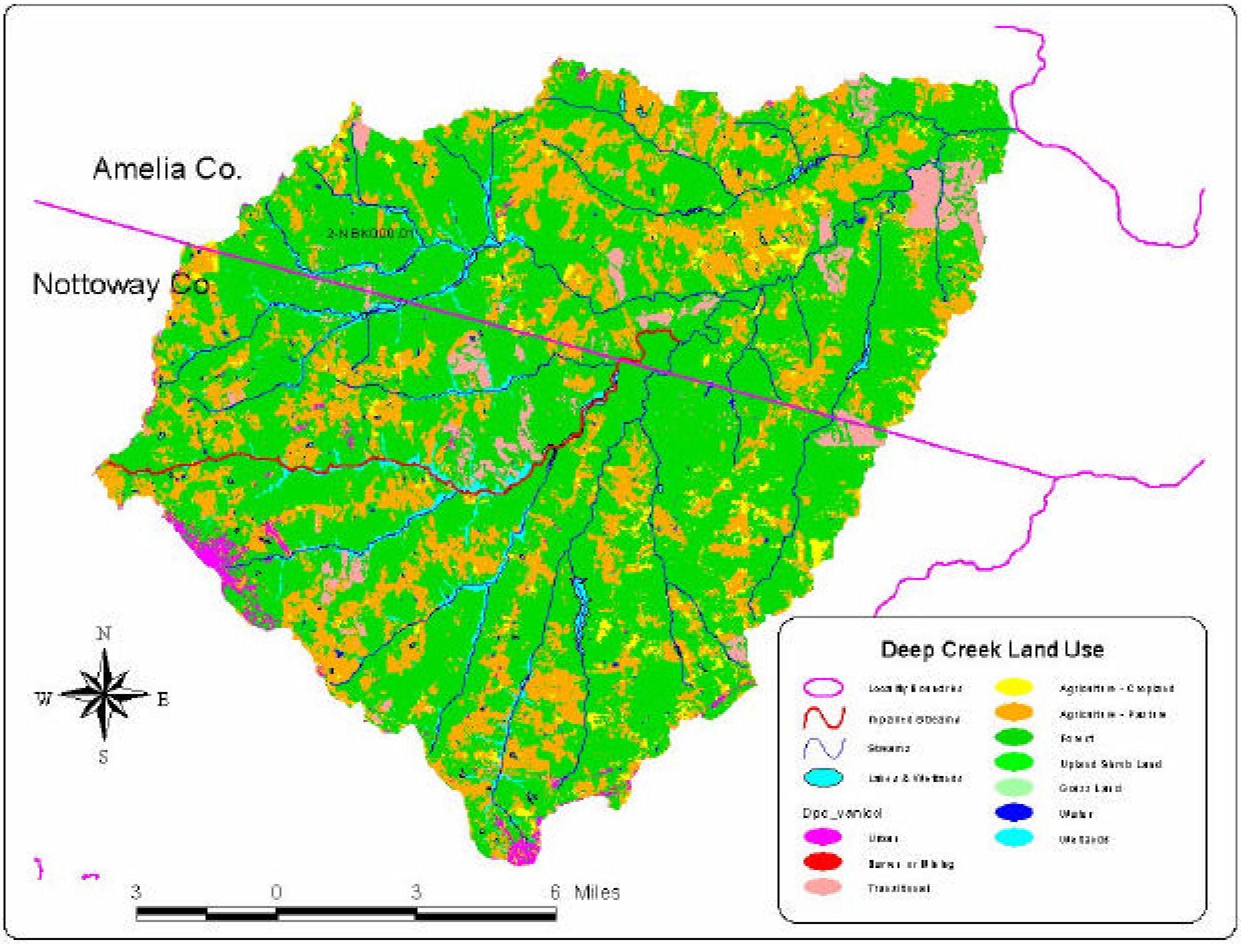
The Deep Creek watershed extends approximately 22 miles upstream from its confluence with the Appomattox River to its headwaters near Crewe, VA, and is about 13 miles wide. The watershed is approximately 131,369 acres in size (205 sq. miles) and is predominately forested (67.7 percent). Agriculture encompasses 24.9 percent of the watershed, with 2.7 percent cropland and 22.2 percent pasture/hayland. Residential and high use industrial areas compose approximately 1.1 percent of the land base. The remaining 6.4 percent of the watershed is comprised of 3.5 percent of transitional areas and 2.9 percent wetlands and open water. Land use is described in Table 3.

A map of the distribution of land use in the watershed (Figure 3) shows that agriculture and forest land cover the majority of the watershed with small areas of urban land in the southwest (Crewe) and south (Blackstone)portions of the basin.

Table 3. Land Use in the Deep Creek Watershed

| **Landuse** | **Acres** | **Sq Miles** | **Percent of Total** |
|---|---|---|---|
| Open Water | 633.8252997 | 0.988767468 | 0.48 |
| Low Intensity Residential | 968.5295369 | 1.510906078 | 0.74 |
| High Intensity Residential | 1.11197421 | 0.00173468 | 0.00 |
| High Intensity Commercial/Industrial/Transportation | 423.4397792 | 0.660566056 | 0.32 |
| Bare Rock/Sand/Clay | 0 | 0 | 0.00 |
| Quarries/Strip Mines/Gravel Pits | 0 | 0 | 0.00 |
| Transitional | 4602.906045 | 7.18053343 | 3.50 |
| Deciduous Forest | 44092.22377 | 68.78386908 | 33.56 |
| Evergreen Forest | 18964.27536 | 29.58426956 | 14.44 |
| Mixed Forest | 25881.86692 | 40.3757124 | 19.70 |
| Pasture/Hay | 29182.42877 | 45.52458888 | 22.21 |
| Row Crops | 3509.613002 | 5.474996282 | 2.67 |
| Other Grasses (Urban/recreational; e.g. parks) | 0 | 0 | 0.00 |
| Woody Wetlands | 2347.822347 | 3.662602861 | 1.79 |
| Emergent Herbaceous Wetlands | 760.8127545 | 1.186867897 | 0.58 |
| | 131368.9 | 204.9 | 100.00 |

**Figure 3. Land Use in the Deep Creek Watershed**




# 3. Description of Water Quality Problem/Impairment

Deep Creek was listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for dissolved oxygen (1998) and fecal coliform bacteria (2004). This report addresses only the DO impairment.

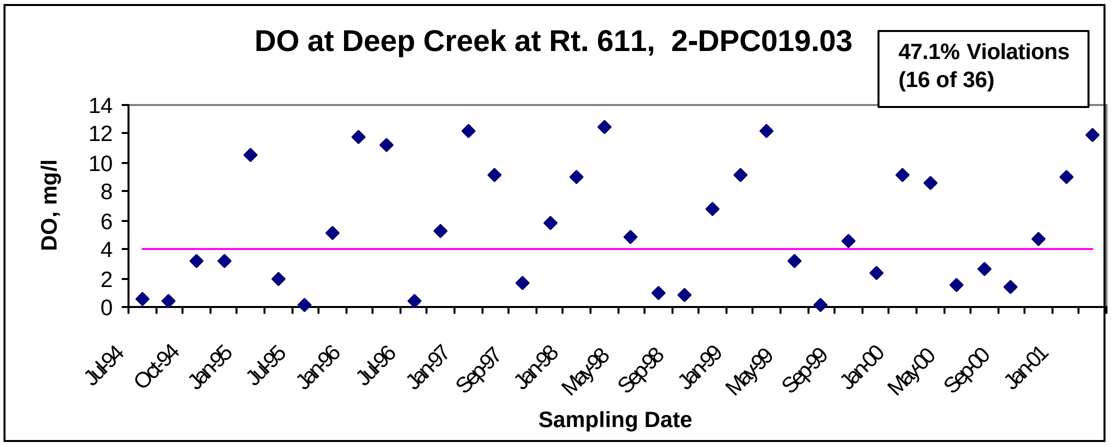
A total of 36 DO data points, with 16 water quality standard violations (47.1%), have been taken by DEQ at station 2-DPC019.03 (see Figure 1) from July 27, 1994 through March 8, 2001 (Table 4).

**Table 4. DO data collected by DEQ on Deep Creek at Rt. 611, 2-DPC019.03**

| | | | | mg/l | | | |
|---|---|---|---|---|---|---|---|
| **Station** | **Date of First Sample** | **Date of Last Sample** | **Number of Samples** | **Average** | **Minimum** | **Maximum** | **Number of Violations** |
| 2-DPC019.03 | 07/27/1994 | 3/8/2001 | 36 | 5.51 | 0.13 | 12.41 | 16 |

A time series graph of all data collected at station 2-DPC019.03 shows the DO concentrations ranging from 0.13 mg/l to 12.41 mg/l (Figure 4). The horizontal line at the DO = 4.0 mg/l mark represents the minimum water quality standard. The data points below the DO = 4.0 mg/l line illustrate violations of the water quality standard.

**Figure 4. Time series of DO Concentrations at Deep Creek at Rt. 611, 2-DPC019.03.**




## *3.1 Associated Mainstem and Tributary site DO*

DEQ added several associated mainstem and tributary monitoring stations during data collection for the low DO assessment of natural conditions or development of a TMDL. Associated station DO data are presented in Figures 5 - 7 below.

**Figure 5. Time series of DO Concentrations at Deep Creek at Rt. 153, 2-DPC005.20.**

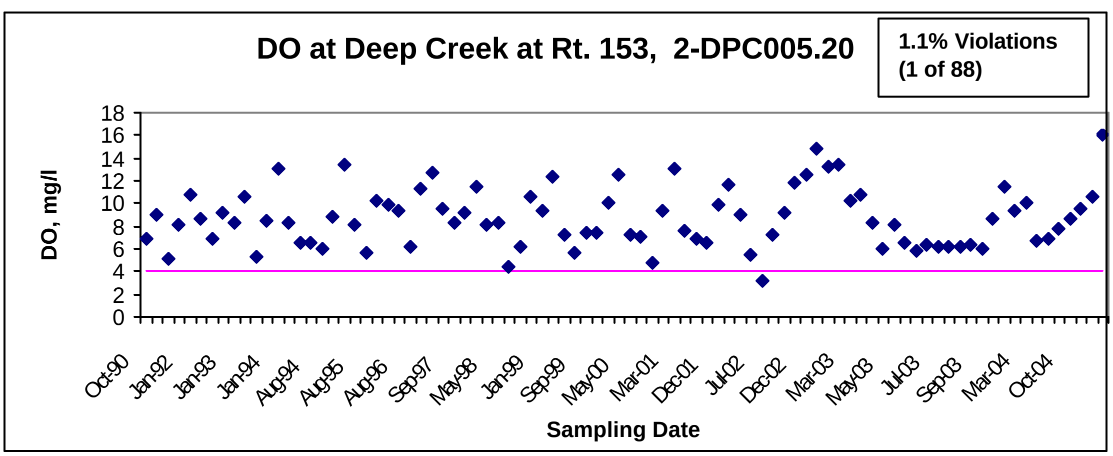



**Figure 6. Time Series of DO Concentrations at Deep Creek at Rt. 615, 2-DPC010.88.**

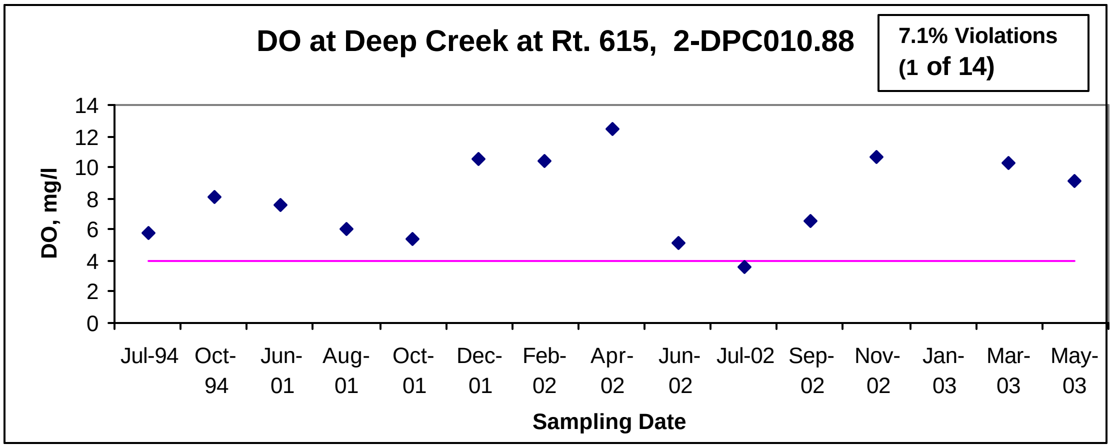
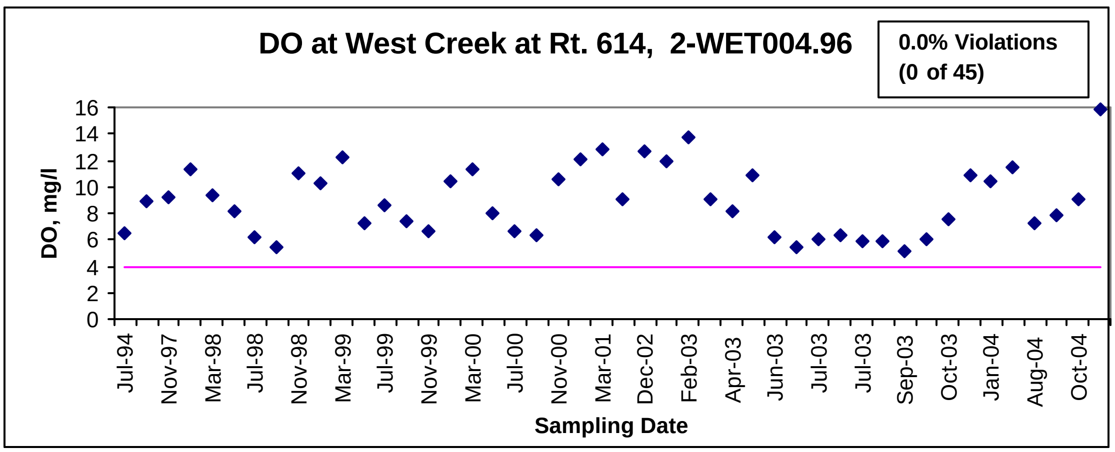



**Figure 7. Time Series of DO Concentrations at West Creek at Rt. 614, 2-WET004.96.**




## *4. Water Quality Standard*

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

### *4.1. Designated Uses*

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Deep Creek must support all designated uses and meet all applicable criteria.

### *4.2. Applicable Water Quality Criteria*

The applicable water quality criteria for pH in the Deep Creek watershed is an instantaneous minimum DO of 4.0 mg/l.

**Table 5. Applicable water quality standards**

| Parameter | Minimum, mg/l | Maximum, mg/l |
|---|---|---|
| *DO* | 4.0 | na |

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

## 5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

**The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.**

# Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

## I. Introduction

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water

Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

## II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

### Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

### Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Deep, Winterpock, and Skinquarter Creeks.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

## III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- average (= assessment period mean) nitrate less than 0.6 mg/L
- average total nitrogen (TN) less than 1.0 mg/L, and
- average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

### *5.1 Preliminary Data Screen for Low Flow 7Q10*

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. There is a long-term flow gaging station on Deep Creek near Mannboro, VA (02041000) on Rt. 153 at rivermile 5.20, with a drainage area of 158 $mi^2$ and a 7Q10 of 1.3 cfs.

Flows at the Deep Creek near Mannboro, VA gage on the dates of DO water quality standard violations at all DO watershed stations in the basin were compared with the 7Q10 flow of 1.3 cfs for the gage. If flows at the Deep Creek near Mannboro, VA gage were below 7Q10, the assumption was made that flows at the DO watershed stations were also below 7Q10.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0 cfs, DO less than 4 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

Performing the preliminary 7Q10 screening on the Deep Creek DO datasets, the results are in Table 6 below. No low DO violations occurred below 7Q10 at listing station 2-DPC019.03, therefore no DO violations were eliminated at this site. However, the lone low DO violations at associated mainstem stations 2-DPC005.20 at the gage and 2-DPC010.88 between the listing station and the gage station, both obtained on July 16, 2002, were below 7Q10, and were eliminated as violations from each dataset.

**Table 6. Deep Creek 7Q10 Flow Vs. DO Violation Screening.**

Deep Creek gage 7Q10= 1.3 cfs, at 158 mi2 drainage area at RM 5.20
At 2-DPC019.03, all DO violations were above 7Q10, so none were eliminated.
At 2-DPC010.88, the only DO violation occurred below 7Q10 on 7/16/2002, and was eliminated.
At 2-DPC005.20, the only DO violation occurred below 7Q10 on 7/16/2002, and was eliminated.

## *5.2 Low slope, Swamps, Wetlands or Large Forested Areas*

There were no discharge measurements made at the Rt. 611 bridge, the original 303(d) listing station. The hydrologic slope from the 250 ft. topographic contour at rivermile 21.21 located 0.1 mi below Rt. 618 downstream to the 200 ft. topographic contour at rivermile 13.26 located 2.4 mi above Rt. 615 is estimated at 0.12%, which is considered very low slope. The approximate upstream and downstream boundaries of this low slope segment on mainstem Deep Creek are from the confluence with Winningham Creek at RM 20.18 downstream to the confluence with Little Creek at RM 14.64. The low slope in this 5.54 mile segment contributes no human impact.

However slope immediately upstream of this segment, from the headwaters of deep Creek at the 480 ft contour at rivermile 28.73 located just below Rt. 360 downstream to the 250 ft contour at rivermile 21.21, located 0.1 mi below Rt. 618, is estimated at 0.58%. This is more than four times the low slope in the downstream DO impaired segment, and above the Swampwater slope guideline of 0.50%.

Visual inspections from bridges at Rts. 615, 614, 611, and 618 revealed large swampy areas in Deep Creek surrounding the Rt. 611 and Rt. 614 bridges. Deep Creek upstream of this reach at Rt. 618 and downstream of the segment at Rt. 615 was in one channel, without swamps. Decomposition of the large inputs of decaying vegetation from swampy areas in this part of the watershed increase oxygen demand and lower DO as they decay. (Figures 8-11).

**Figure 8. Deep Creek at Rt. 615.**

**Figure 9. Deep Creek at Rt. 614.**

**Figure 10. Deep Creek at Rt. 611.**

**Figure 11. Deep Creek at Rt. 618.**


## *5.3 Instream Nutrients*

The VADEQ collected nutrient data from station 2-DPC019.03 at Rt. 611 from July 1994 to March 2001 (Table 7). The average nutrient concentrations are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + $NO_3$ + $NO_2$) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

**Table 7. Instream Nutrients, BOD5, TSS of Deep Creek at Rt. 611, 2-DPC019.03.**

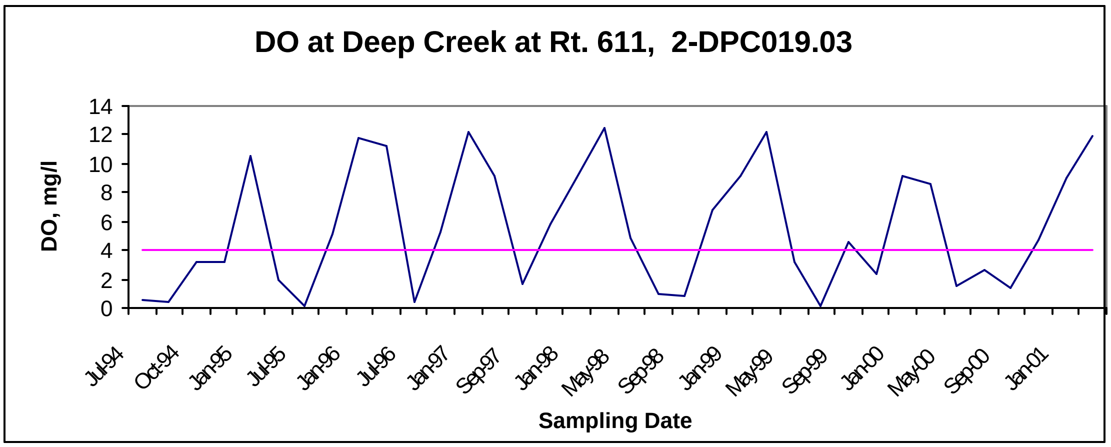
| Parameter | Average Conc. | Number | |
|---|---|---|---|
| **Total Phosphorous** | **0.075 mg/l** | (n=34) | |
| Orthophosphorous | 0.055 mg/l | (n=35) | |
| Total Kjeldahl Nitrogen | 0.576 mg/l | (n=34) | |
| Ammonia as N | 0.046 mg/l | (n=35) | |
| **Nitrate as N** | **0.111 mg/l** | (n=35) | |
| Nitrite as N | 0.010 mg/l | (n=35) | |
| **TN (TKN + $NO_3$ + $NO_2$)** | **0.701 mg/l** | (n=34) | |
| $BOD_5$ | 1.385 mg/l | (n=34) | (max = 5.0 mg/l occurred once) |
| TSS | 5.750 mg/l | (n=34) | (max = 30 mg/l once) |

These levels of nitrate, total nitrogen and total phosphorus (bolded in black) are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + $NO_3$ + $NO_2$) < 1.0 mg/l; and TP < 0.1 mg/l.

### *5.4 Natural Seasonal DO Fluctuation*

Deep Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 17.

**Figure 12. Seasonal Variation in DO at Deep Creek at Rt. 611, 1994 – 2001.**




### *5.5 Impact from Point Source Dischargers and Land Use*

There are 19 permitted dischargers in the Deep Creek watershed: three VPDES point source discharges (one of which is closed), one VPG CAFO with no permitted discharge, three VAG single family home domestic discharges, one VAG NMMM quarry discharge, five VAR industrial stormwater discharges, and six VAR construction stormwater discharges in the Deep Creek watershed. These are described in Table 8 and Figure 13 below. Seven of these discharges are located upstream of the low DO segment and are highlighted in Red in Table 8.

Of the seven permitted dischargers in the Deep Creek watershed upstream of the original listing station, 2-DPC019.03, only the Crewe STP located on a UT to Deep Creek 7.5 miles upstream of the listing station, is of sufficient flow to consider the possibility of impact. Its design flow is 0.50 MGD (0.78 cfs). Mean flow at the Deep Creek listing station is 18 cfs by drainage area ratio with the Deep Creek near Mannboro, VA gaging station. On average, Crewe STP effluent comprises approximately 5% of flow at 2-DPC019.03. Therefore potential effect more than seven miles downstream at the listing station from the Crewe STP flow will be minimal. In further support of this statement, low nutrients, BOD5 and TSS (see Table 7) at 2-DPC019.03 show that the discharge has no significant anthropogenic impact on the low DO impaired segment.

EPA approved a benthic TMDL for the UT to Deep Creek below this STP in 2004, with the stressor identified as overflows from the town sewer system. This facility had solids discharge events in the 1980's and early 1990's that impacted the UT to Deep Creek, however adverse impact to mainstem Deep Creek was not documented. The town upgraded the STP in 1997, and the most recent benthic assessment in 2002 indicated no impairment. The mouth of this UT is 5.4 miles above the original low DO listing station. Therefore solids releases in the UT to Deep Creek below Crewe STP in the 1980's and early 1990's probably have no current impact in the swampy segment in mainstem Deep creek more than five miles downstream.

**Figure 13.  VPDES dischargers in the Deep Creek Watershed**

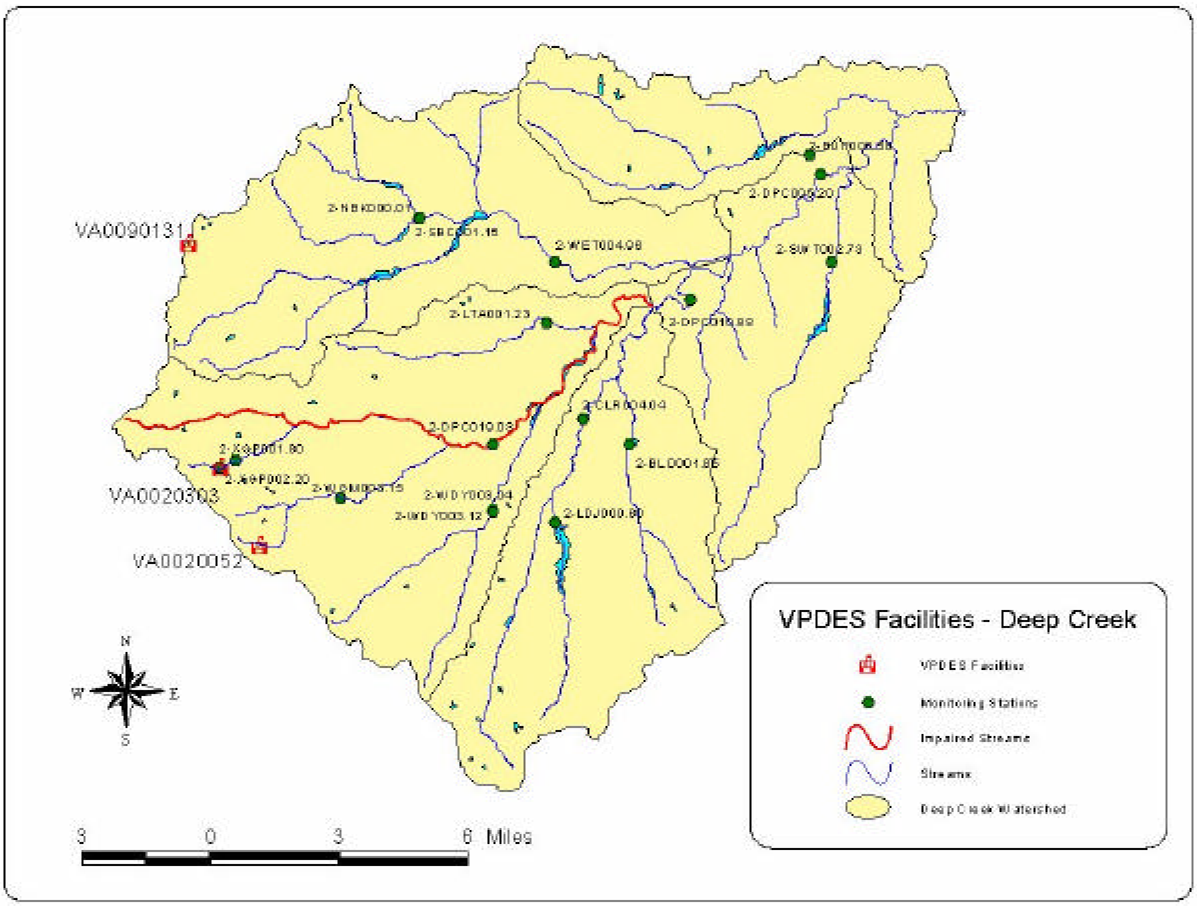


**Table 8. VPDES, VPG, VAG and VAR point source facilities**

| Stream Name | Facility Name | VPDES Permit Number | Discharge Type | Design Flow (MGD) | Permitted *CBOD5* or *BOD5* Limit | Permitted *TKN* Limit | Permitted *TSS* Limit |
|---|---|---|---|---|---|---|---|
| UT to Winningham Creek | Crewe Primary School | VA0020052 | **Expired 1997, lagoon closed** | 0.001 | Unk | Unk | Unk |
| UT to Deep Creek | Crewe WWTP | VA0020303 | Municipal Minor | 0.50 | 12 mg/l CBOD5 | 3.0 mg/l | 12.0 mg/l |
| UT to West Creek | Tyson Foods Inc. Feed Mill | VA0090131 | Industrial Minor | 0.012 | NL | NL | NL |
| Beaverpond Creek | RM Watkins and Son, Land Vue Farm | VPG140037 | CAFO | ND | ND | ND | ND |
| UT to Bland Creek | Dagner, John A Residence | VAG404075 | Domestic | <0.001 | 30 mg/l, maximum | NL | 30 mg/l, maximum |
| UT to Cellar Creek | Eckmann, Harold A Residence | VAG404126 | Domestic | <0.001 | 30 mg/l, maximum | NL | 30 mg/l, maximum |
| UT to Winningham Creek | Barnes, Brenda Residence | VAG404156 | Domestic | <0.001 | 30 mg/l, maximum | NL | 30 mg/l, maximum |
| Deep Creek | Amelia Sand Co. | VAG844043 | NMMM | NL | NL | NL | 30 mg/l, maximum |
| UT Maplewood, and Maplewood Branch | Maplewood Recycling and Waste Disposal | VAR050622 | Industrial Stormwater | NL | 37 mg/l average | 4.9 mg/l ammonia, average | 27 mg/l, average |
| Lees Creek | Nottoway Lumber Co. | VAR050689 | Industrial Stormwater | NL | NL | NL | 100 mg/l, maximum |
| Cellar Creek | Taylor Ramsey Blackstone Wood Preservers Inc. | VAR050706 | Industrial Stormwater | NL | NL | NL | 100 mg/l, maximum |
| UT to Winningham Creek | Crewe Municipal Airport | VAR051177 | Industrial Stormwater | NL | 30 mg/l, maximum | 1.5 mg/l, maximum | NL |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cellar Creek | Nottoway Co. Sanitary Landfill-Blackstone | VAR051577 | Industrial Stormwater | NL | NL | NL | NL |
| UT to Winningham Creek | VDOT Richmond District 0618067168 C502 | VAR100205 | Construction Stormwater | NL | NL | NL | NL |
| Buckskin Creek | VDOT Richmond District 6400640004 P87M501 | VAR100439 | Construction Stormwater | NL | NL | NL | NL |
| UTs to Watson and Cellar Creeks | VDOT Amelia 0614067174 M501 | VAR101785 | Construction Stormwater | NL | NL | NL | NL |
| UT to West Creek | VDOT Amelia 0660004P94 M501 | VAR101790 | Construction Stormwater | NL | NL | NL | NL |
| UT to Winningham Creek | VDOT Amelia 0618203168 C501 | VAR101817 | Construction Stormwater | NL | NL | NL | NL |
| UT to Lees Creek | Virginia Army National Guard - MATES | VAR103200 | Construction Stormwater | NL | NL | NL | NL |

NL = No limit, Unk = Unknown, ND = No discharge

Residential and high use industrial areas (1393 acres) compose approximately 1.06 percent of the land base. The watershed is predominately forested (67.7 percent), with 2.9 percent wetlands and open water. This land use was considered not indicative of human impact.

## 6.0 CONCLUSION

***The following decision process is proposed for determining whether low DO values are due to natural conditions:***

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background

- average (= assessment period mean) nitrate less than 0.6 mg/L
- average total nitrogen (TN) less than 1.0 mg/L, and
- average total phosphorus (TP) are less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

Deep Creek from Rt. 618 downstream to between Rts. 614 and 615 exhibits low slope (0.12%) with significant large swampy areas. The boundaries of this low slope segment are approximately from the confluence with Winningham Creek downstream to the confluence with Little Creek. The approximate length of this swampy area, which includes the original listing station, is 5.54 miles. Large swampy areas contribute large inputs of decaying vegetation, which when decomposed by bacteria in the water lower DO as they decay. These are not considered anthropogenic impacts.

However slope upstream of this segment, from the Rt. 618 bridge upstream to the headwaters of Deep Creek just below Rt. 360, is estimated at 0.58%. This is more than four times the low slope in the downstream low DO segment, and above the swampwater slope guideline of 0.50%.

Deep Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, as well as low BOD5 and low TSS, which are not indicative of human impact.

There are seven permitted dischargers in the Deep Creek watershed upstream of the low DO listing station, however only the Crewe STP, located on a UT to Deep Creek 7.5 miles upstream of 2-DPC019.03, is of sufficient flow to consider the possibility of impact. Its design flow is 0.50 MGD (0.78 cfs). On average, Crewe STP effluent comprises approximately 5% of flow at 2-DPC019.03, therefore potential effect from Crewe STP flow at the listing station will be minimal, as shown by the nutrient, BOD5 and TSS concentrations.

EPA approved a benthic TMDL for the UT to Deep Creek below this STP in 2004, with the stressor identified as overflows from the town sewer system. This facility had solids discharge events in the 1980's and early 1990's that impacted the UT to Deep Creek, however adverse impact to mainstem Deep Creek was not documented. The town upgraded the STP in 1997, and the most recent benthic assessment in 2002 indicated no impairment. The mouth of this UT is 5.4 miles above the original low DO listing station. Therefore solids releases in the UT to Deep Creek below Crewe STP in the 1980's and early 1990's probably have no impact in the swampy segment five miles below Rt. 618. Runoff from Residential / Commercial land use (1.06%) probably has no DO effect on the watershed.

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for mainstem Deep Creek from the confluence with Winningham Creek downstream to the confluence of Little Creek, a distance of 5.54 river miles. If there is a 305(b)/303(d) assessment prior to the reclassification, Deep Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

### *7.0. Public Participation*

DEQ performed the assessment of the Deep Creek low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

## 8. References

Maptech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia. 2003.

SRCC (Southeast Regional Climate Center)
http://www.dnr.state.sc.us/climate/sercc/products/historical/historical_va.html (Accessed 12/18/02)

USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 1998. Virginia. 1998.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 2002. Virginia. 2002.

# Appendix A

# Glossary

## GLOSSARY

**Note: All entries in italics are taken from USEPA (1998). All non-italicized entries are taken from MapTech (2002).**

**303(d).** A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

**7Q10.** The lowest streamflow for seven consecutive days that occurs on average once every ten years.

***Ambient water quality.*** *Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.*

***Anthropogenic.*** *Pertains to the [environmental] influence of human activities.*

***Background levels.*** *Levels representing the chemical, physical, and Bacterial conditions that would result from natural geomorphological processes such as weathering or dissolution.*

***Best management practices (BMPs).*** *Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.*

***Clean Water Act (CWA).*** *The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.*

***Concentration.*** *Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).*

**Confluence.** The point at which a river and its tributary flow together.

***Contamination.*** *The act of polluting or making impure; any indication of chemical, sediment, or Bacterial impurities.*

***Designated uses.*** *Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.*

***Dilution.*** *The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.*

***Direct runoff.*** *Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.*

***Discharge.*** *Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.*

***Discharge permits (under VPDES).*** *A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.*

***Domestic wastewater.*** *Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.*

***Drainage basin.*** *A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.*

***Effluent.*** *Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.*

***Effluent limitation.*** *Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.*

***Existing use.*** *Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).*

**GIS.** Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

***Hydrologic cycle.*** *The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.*

***Hydrology.*** *The study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.*

***In situ.*** *In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.*

***Margin of safety (MOS).*** *A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the* *receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).*

**Mean.** The sum of the values in a data set divided by the number of values in the data set.

**MGD.** Million gallons per day. A unit of water flow, whether discharge or withdraw.

***Monitoring.*** *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

***Narrative criteria.*** *Nonquantitative guidelines that describe the desired water quality goals.*

***National Pollutant Discharge Elimination System (NPDES).*** *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

***Natural waters.*** *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

***Non-point source.*** *Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.*

***Numeric targets.*** *A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

***Organic matter.*** *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

***Peak runoff.*** *The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.*

***Permit.*** *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

***Point source.*** *Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.*

***Pollutant.*** *Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, Bacterial materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).*

***Pollution.*** *Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, Bacterial, chemical, and radiological integrity of water.*

***Public comment period.*** *The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).*

***Raw sewage.*** *Untreated municipal sewage.*

***Receiving waters.*** *Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.*

***Restoration.*** *Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.*

***Riparian areas.*** *Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.*

***Riparian zone.*** *The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.*

***Runoff.*** *That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.*

***Slope.*** *The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).*

**Stakeholder.** Any person with a vested interest in assessment of natural condition or TMDL development.

**Standard.** In reference to water quality (e.g. pH 6 – 9 SU limit).

***Storm runoff.*** *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

***Streamflow.*** *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

***Stream restoration.*** *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

***Surface area.*** *The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

***Surface runoff.*** *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

***Surface water.*** *All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

***Topography.*** *The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

***Total Maximum Daily Load (TMDL).*** *The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.*

***Tributary.*** *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

**Variance.** A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.

**DCR.** Department of Conservation and Recreation.

**DEQ.** Virginia Department of Environmental Quality.

**VDH.** Virginia Department of Health.

***Wastewater.*** *Usually refers to effluent from a sewage treatment plant. See also* ***Domestic wastewater****.*

***Wastewater treatment.*** *Chemical, Bacterial, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.*

***Water quality.*** *The Bacterial, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.*

***Water quality criteria.*** *Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.*

***Water quality standard.*** *Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.*

***Watershed.*** *A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*